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OUTSTANDING PEDAGOGICAL PRINCIPLES NOW FUNCTIONING IN HIGH-SCHOOL MATHEMATICS.

Are teachers of mathematics in high schools concerning themselves with ways and means of rendering more efficient professional service? It is the writer's purpose to adduce some facts that may serve partially to answer this question.

In the first place it may be worthy of note that teachers of high-school mathematics are much less given to reliance upon the teaching tactics of their favorite collegiate model than they were a few years since. They do not now listen in silent awe to collegiate preachments on the *what* and *how* of high-school mathematics to any such extent as was recently the practice. There has recently come into existence among high-school teachers a real faith that more psychological teaching is better teaching. In seeking an answer to the question asked above we may then set aside the imitation of collegiate favorites and take up the question of accepted pedagogical and psychological principles of today.

One may even see in the multiplicity of active organizations of teachers of high-school mathematics, in the numerous significant reports of recent date of commissions, councils, committees and bureaus all pointing out the urgent need and sketching the desired trend of improvement in high-school mathematics, in numerous recent textual attempts at reform, etc., that high-school teachers of mathematics are alive to the need of greater efficiency of teaching and are concerning themselves actively to bring it about.

The question however that always remains in one's thought is to what extent are the findings of these reports being accepted and followed even by those who aid in formulating and advocating them. Is classroom practice reshaping itself in the light of these studies and their recommendations? Let us remember that teaching acts are born of ideas that have become teaching *ideals*. Sound attempts at improvement do not forerun, but follow, ideals of worthier achievement. The teacher will persist in seeking improvement only so long as his ideals of worthier professional performance impel him to it. Hence the question here mooted: What are some of the outstanding pedagogical principles that have recently become acceptable to high-school teachers of mathematics? These principles will function, so to speak, as fulcra for our lever to pry into the present status of reformative practices. Later we may diagnose tendencies, for accepted and applied principles must generate tendencies, but it is doubtful whether anything yet exists of sufficient strength or stretch to warrant the name of tendency.

What psychological or pedagogical principles are accepted in mathematical high school practice may be gauged with some reliability from widely used texts, from reports and monographs of associations and bureaus and from observation of actual classroom practice. While the writer has tested some of the principles stated below, by comparison with these sources, he has sought to derive them largely by personal contacts with some fifty or more siginificant high-school teachers. Accepted principles may then mean either (1) merely assented to intellectually but not definitely used, or (2) accepted and applied in practice.

My first principle is rather a complicated one, but as it is a very consequential one, it may well be set forth as compartly as seems feasible.

PEDAGOGICAL AND PSYCHOLOGICAL PRINCIPLES.

I. *Efficient teaching of high-school mathematics derives its efficiency mainly from the following five fundamentals of teaching technics:*

(*a*) A clear and compelling conception of the master aims and purposes to be striven for in each year of the high school,

(*b*) The ability to judge, to choose and to employ matter and method that will yield an appreciable measure of these aims and purposes with a majority of the pupils, (*c*) The technical skill to determine objectively from time to time the degree of progress being made toward these aims and purposes,

(*d*) The generalship so to alter teaching strategics in the light of the findings, as to attain the goals of the year with the majority of the pupils,

(*e*) The tact and skill to attain the destined ends without impairing the native taste and enthusiasm for mathematical learning.

It is now difficult, indeed, to find a significant teacher of high-school mathematics who does not concede the psychological justifiability of these five fundamentals. The teacher may claim that the adopted text which he must use makes it difficult for him to practice his belief, but the point is that it is his belief. No single dissenter has been found to the justifiability or feasibility of such a measure of professional expertness as will enable the teacher of mathematics to meet all five requirements. This means much for future improvement, for less than ten years ago these things were called "pedagogic vaporings."

II. *Social worth and psychological justifiableness are commonly accepted as criteria in both elementary and secondary mathematics. Utility and adaptability are the accepted tests of material to be selected.*

It has been but a few years since the high-school teacher, when reminded of the low value to modern society of some topic of advanced arithmetic, or of algebra or demonstrative geometry, arrayed himself at once in defence of the topic, and against the social criterion. The disciplinary virtues of the school subjects furnished him safe refuge from the impertinent criterion of social worth. Only a few years ago one significant teacher asserted that to study mathematics with concern for its utility greatly impaired the value of that study. Its worth to the student was in direct proportion to the degree of completeness with which he could divest himself of all notions of its usefulness. This attitude is today confined almost entirely to our colleges and universities. No important high-school teacher takes it. He reminds us at once that he and his significant colleagues have veered to the recognition of the following as a leading principle of curriculum-building for high-school mathematics:

Those truths, principles and methods should be included which yield the most effective control of the world of space and time and are at the same

time richest in their mathematical interrelationships. This dual type of material must be persistently attended to in teaching, though the outward aspect upon the world of reality should receive first and main emphasis in the high-school work.

This very rational, and comprehensively sane point of view seems to cover sufficiently the requirement of social worth, without sacrificing either scientific or psychologic soundness. May we not hope soon to see a high-school course of mathematical study really organized on this wholesome basis.

Psychological justifiability was hardly thought of as applicable to high-school teaching of mathematics a few years since. That the form and matter of mathematics should be materially and qualitatively modified from the type for adult presentation to adapt it to immaturity might be well enough for the elementary school. The high-school must take up the more virile task of mastering the logic of mathematical studies. This viewpoint has so much softened with recent years that one rarely hears nowadays of logic as an important aim of mathematics in the high-school. The good high-school teacher of today admits at once that the mathematical course of study which gives to the pupil at each maturity-level the particular type of knowledge and skill that are best suited to this level, with but minor regard to preparatory needs, is of supreme importance. This seems sufficiently to support my point that psychological justifiability has in recent years become an accepted fundamental principle of high-school teaching of mathematics.

III. *General acceptance of the doctrine of correlation in teaching early high-school courses, together with its natural corollary of general mathematics for these courses, is a third principle of recent acceptance by secondary mathematics teachers.*

A dozen years ago the doctrine of correlation was regarded as a fad by high-school teachers of mathematics. Those who may have been connected with the editing of high-school journals twelve or more years ago have not forgotten how it endangered the subscription list of journals for high-school teachers to champion the merits of correlation too earnestly. Teacher-training classes also at that time showed a decided aversion to being treated too generously with this doctrine. One must search far and widely nowadays to find a high-school teacher who opposes correlation in teaching. Most of them are the warmest advocates of it, and stoutly profess to be making continual use of it. Mathematical times do change, and in the present instance the change has been for the better. An all-around correlation of all kindred high-school subjects, not merely with the mathematical branches among themselves, is indeed now quite the order of the day. In this regard we can exclaim with Galileo: "*E pur si muove.*"

Not all teachers have reached the point at which they are ready to accept general, or combined, mathematics as the necessary consequence of correlation, but most significant high-school professionals are ready to admit it as legitimate and under certain conditions, desirable. May we soon see the day in which high-school teachers of mathematics, generally, shall see that general mathematics for early high-shool courses is the only plan in full harmony with the spirit and educational psychology of our time. The extent of textual material and of the highly successful use of it in mathematical classes over the entire country have already taken from it the odium of mere local interest and significance which for some time it had. It will hardly be news to the up-to-date high-school teacher of mathematics that general mathematics is a most significant national movement. The success of this movement in high-school mathematics has been so marked that even many universities are employing combined mathematics in early courses. General mathematics is one of the leading recent high-school movements toward radical improvement.

IV. *Recognition of the urgent need for a general agreement as to what are the legitimate attainable purposes of secondary-school mathematics, to be used as a basis for a soundly reorganized modern course of study in both the junior and senior high schools constitutes our fourth pedagogical principle of recent acceptance.*

If this principle is a valid statement of a recently accepted view, it implies some rather significant things. In the first place, it implies the general recognition that thoroughgoing change is needed in the course of study in high-school mathematics; that there is grave danger that the change may not be for the better; that it needs united counsel and support, and that now is the time to undertake reorganization. Perhaps some of these things arise from the fact that the plans already proposed, some of which are already embodied in texts, differ so widely in scope and nature as to make the average teacher wonder where the correct route may finally be found to lie. One can see in this statement also that it is desirable that the set purposes, whatever they be, shall be definitely attainable. Too often in the past the purposes set by the course of study or by the individual teacher, however worthy they may have seemed, have not been achieved by a sufficient number of pupils to demonstrate their legitimacy. If all these things are correct implications of a correctly stated principle, we may justly look for greater forward movement in high-school teaching of mathematics than the last fifty years have seen.

V. *Recognition of the fundamental and controlling place of the notion of functionality throughout the secondary mathematical curriculum may in the writer's opinion*, though he would be glad of a little higher certainty here, *be claimed as a recently accepted pedagogical principle by strong high-school teachers of mathematics.*

Recently it came to the knowledge of the writer that a leading high-school teacher whose success as a teacher has won the enviable distinction of functioning as an advisor to school officials of an important state, holds and voices the view that while collegiate people regard functionality as entitled to a dominant place in high-school mathematics, high-school teachers themselves see little or nothing in the idea. If this advisor is correct then the writer is incorrect in claiming this principle to have won recent acceptance from high-school teachers. The rather extensive poll the writer has made, as well as the written statements of high-school teachers in journals and elsewhere, lead him to believe that all high-school teachers who understand the principle, accept it. Since this could not by any stretch of imagination have been claimed half a dozen years ago, it is included here as entitled to the list of pedagogical principles recently accepted by high-school teachers of mathematics.

VI. *Ideal teaching of high-school mathematics consists in so implanting a definite quantum of mathematical knowledge and skill that the learner will, in the learning acts, develop right study habits and skill in applying knowledge.*

It is believed that the principle just stated lies in the background of the professional consciousness of all high-school teachers today, and it is certainly in the foreground of consciousness of many. A few years ago the problem of ideal teaching could not be stated so sharply as the work of the last few years have made it possible to do. Perhaps once it is stated in this simple form, it'will be accepted by most high-school teachers after a little consideration. Whether generally accepted or not, however, it is of sufficient value as a definition and of sufficient acceptability to many significant teachers to merit its inclusion in the list of principles of recent acceptance.

VII. *Good high-school mathematics and good mathematical teaching are chiefly beneficial to the public-school pupil anywhere because, and in so far as, they beget and foster the habit of taking a rational attitude toward problematic situations, i.e., the habit of basing conclusions on the underlying facts.*

Every American voter needs this habit strengthened to the fullest measure of which he is capable. If the high-school teacher has not already accepted this as the leading purpose of American school mathematics to the ordinary citizen, its mere statement will be sufficient to gain his acceptance of it. It is the chief reason why we cannot afford to allow the mathematical element in education be reduced to the *minimum essentials*. We need the questions of the day settled not on the basis of its being accepted, or rejected, by one's favorite political leader or party, but solely on the basis of *the underlying facts*. No subject of the high-school curriculum is better adapted to this educational need than mathematics.

The writer must abstain from adding a few more vital principles of recent acceptance. It would seem that the more significant ones stated above will suffice for an affirmative answer to the question raised at the beginning of this paper.

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